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I also certify that the attached copy of the request for grant of a Patent (Form 1/77) bears a correction, effected by this office, following a request by the applicant and agreed to by the Comptroller-General.

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Dated 9 March 2004

Patents Form 1/77

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Request for grant of a patent

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13AUG01 E652336-2 D00239
P01/7700 0.00-0119659.1

1.	Your reference	P11699GB\DM\RP\AM
2.	Patent application number *(The Patent Office will fill in this part)*	11 AUG 2001 **0119659.1**
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)* 0079820004 Patents ADP number *(if you know it)* GT F1/77 7.6.02 If the applicant is a corporate body, give the country/state of its incorporation	THE UNIVERSITY Court of the University of Dundee ~~UNIVERSITY OF DUNDEE~~ NETHERGATE PERTH ROAD DUNDEE DD1 4HN UNITED KINGDOM
4.	Title of the invention	IMPROVED FIELD EMISSION BACKPLATE
5.	Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* Patents ADP number *(if you know it)*	CRUIKSHANK & FAIRWEATHER 19 ROYAL EXCHANGE SQUARE GLASGOW G1 3AE SCOTLAND UNITED KINGDOM 547002 ✓
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country — Priority application number *(if you know it)* — Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application — Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	9
Claim(s)	
Abstract	
Drawing(s)	2 +2

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature

CRUIKSHANK & FAIRWEATHER

Date 10 AUGUST 2001

12. Name and daytime telephone number of person to contact in the United Kingdom

DR DAVID MORELAND
0141 221 5767

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IMPROVED FIELD EMISSION BACKPLATE

FIELD OF INVENTION

The present invention relates to a field emission backplate and related arrangement, and in particular though not exclusively, to a field emission backplate comprising a plurality of emission sites or "silicon tips" formed by laser crystallisation e.g. for use in a display.

BACKGROUND TO INVENTION

Flat panel displays are of immense importance in electronics. In current developments, Active Matrix Liquid Crystal Displays (AMLCD) are beginning to challenge the dominance of Cathode Ray Tube (CRT) technology. AMLCD devices are non-emissive and require complex lithography. Filters and matching spectral backlights are required to produce colour. However, there are many light losses and inherent complexity in AMLCD devices because of the non-linear nature of liquid crystal materials. This results in a display that is less bright than CRT with a smaller colour gamut and poorer viewing angle and contrast. Also, due to the non-emissive nature of the display, inefficient use of input electrical power is made often with well over 70% of the energy being lost as non-useful energy.

Field emission displays, based on conventional 'Spindt

tip' technology, promised a solution to flat panel display problems. Field emission displays (FEDs) are essentially flat cathode ray tube (CRT) devices. However, rather than one electron gun firing electrons at a phosphor on a screen through a shadow mask, the FED has tens or hundreds of individual tips in each display pixel. The tips are known as Spindt tips, after the inventor Cap Spindt. The process of fabrication relies on defining a pattern of holes in a gate metal by leaving a well beneath the metal. A sacrificial layer (usually nickel) is then evaporated on the surface at an oblique angle to ensure the well is not filled. The emitter material (usually tungsten or molybdenum is then evaporated through the holes in to the well. As the evaporate metal builds up on the surface, on the sacrificial layer, it closes the hole as the thickness increases, and has the effect of providing an emitter tip in the well. The top metal is then removed by etching the sacrificial layer, leaving the tip, the well, and the original gate metal. This forms the back plate of Spindt tips. A top plate containing a patterned phosphor is then placed using spacers. The final device is evacuated to allow the emitted electrons a long mean free path. The principle of field emission from micro-tips is well understood and is governed by Fowler - Nordheim tunnelling. The emission current, and therefore brightness of the display depends then only on the current density, the

number of tips and their sharpness, i.e.

$I = J_{FN}\ n^{\alpha}$

Where n = number of tips, α the tip sharpness and J_{FN} the Fowler-Nordheim tunnel current density.

The tips will provide a sharp electron source that will provide hot electron injection into, for example, a phosphor.

Unfortunately, the extreme complication in fabrication has limited the use of this technology. Additionally, crystal silicon emitters are limited by the wafer size.

Other thin-film materials may also be used for field emission. Carbon is the main contender with diamond, diamond like carbon and carbon nano-tubes also suitable. The diamond seemed a good choice, although it is difficult to fabricate and also the mechanism of a supposed negative electron affinity which diamond was claimed to have has now been questioned.

An object of the present invention is to obviate or mitigate at least one of the aforementioned problems.

SUMMARY OF INVENTION

According to a first aspect of the present invention there is provided:

a method of forming a field emission backplate comprising:

providing a planar body of amorphous semiconductor based material upon a substrate; and

laser crystallising at least a portion of the

amorphous semiconductor based material;

wherein upon crystallising the amorphous semiconductor based material a plurality of emitter sites are formed.

Preferably the planar body of amorphous semiconductor based material is provided by depositing a thin film of the material upon a substrate.

Conveniently, the semiconductor based material is silicon or an alloy thereof.

Preferably the laser crystallising is performed using an excimer laser or Nd:YAG laser.

Conveniently, the excimer laser is a KrF laser.

According to a second aspect of the invention there is provided a field emission backplate comprising a plurality of emitter sites formed by laser crystallisation of a thin film of amorphous semiconductor based material.

Conveniently, the semiconductor based material is silicon or an alloy thereof.

According to a third aspect of the invention there is provided a field emitting device comprising a field emission backplate having a plurality of emitter sites formed by laser crystallising of a thin film of amorphous semiconductor based material.

Preferably the field emission device is a vacuum device wherein the emitter sites of the backplate acts as an emission source in the device.

Conveniently, the field emission device comprises a substrate, a field emitting backplate, and an evacuated

space and a transparent window, e.g. thin film transparent metal or metallised phosphor, wherein the field emission backplate is formed upon the substrate and the evacuated space is located between the field emitting backplate and the thin film transparent metal or metallised phosphor.

Alternatively, the field emission device further comprises a wide band-gap light emitting material, e.g. light emitting polymer into which electrons from the emitter sites of the backplate are emitted.

Conveniently, the field emission device comprises a substrate, a field emitting backplate, one side of which is formed a plurality of emitter sites, a light emitting polymer and a thin film transparent metal or metallised phosphor wherein a field emitting backplate is formed upon the substrate, one surface of the light emitting polymer is disposed on the plurality of emitter sites of the light emitting backplate, the thin film transparent metal being disposed on the other surface of the light emitting polymer.

Conveniently, the field emission device is a display device.

BRIEF DESCRIPTION OF DRAWINGS

These and other aspects of the invention will become apparent from the following description when taken in combination with the accompanying drawings which show:

Figure 1A - 1F a thin film semiconductor crystallised at various energies according to the present invention.

Figure 2 a field emission device according to an embodiment of the present invention; and

Figure 3 a graph of field emission current vs electric field for a field emission backplate according to the present invention.

DETAILED DESCRIPTION OF DRAWINGS

With reference to Figures 1A - 1F there is shown a field emitter backplate formed of a amorphous semiconductor based material, in this case n-type hydrogenated amorphous silicon, on the surface of which a plurality of emitter sites are formed. The field emitter backplate is formed by the deposition of a thin film of approximately 100 nm of n-type hydrogenated amorphous silicon onto a substrate of, for example, aluminium by plasma enhanced chemical vapour deposition (PECVD). The deposited thin film then undergoes laser crystallisation by an excimer laser or Nd:YAG laser, in this case a KrF laser operating at a wavelength of 248 nm scanning at 2 mm\s in an atmosphere of oxygen and then quenched, or a Nd:YAG laser operating at a wavelength of 532 nm pulsed at 3 to 7 nseconds, stepped and repeated to form a pattern. This process results in the surface of the silicon having a rough texture. The energy absorbed by the silicon, influences the extent of roughening of the surface, as can be seen in Figures 1A - 1F, with Figure 1A showing the effect of a small amount of absorbed energy to

Figure 1F i.e. approximately 100 mJ\cm^2 which shows the rounded tips achieved by the most absorbed energy, in the region of 300 mJ\cm^2. In each case, each of the tips acts as an emitter site. In a field emission device an emitter site emits electrons at low fields in a field emission configuration. The backplate results in emission currents in excess of 10^{-5}A and low field threshold of around 10Vμm.

An example field emission device, having a field emission backplate formed as described with reference to Figures 1A - 1F, is shown in Figure 2. The device shown is a triode device having a field emission backplate with a substrate of aluminium and a thin film of n-type hydrogenated amorphous silicon which has been treated by an excimer laser and thus has a plurality of emitter sites upon the surface an insulating layer, for example, a layer of an insulating material such as silicon nitride, has been disposed on the crystallised silicon, and subsequently etched thus providing spacer elements. Upon each of these elements is disposed a thin film of phosphor, e.g. metallised phosphor and the device is completed with a layer of glass thus giving a three terminal gate control arrangement. The area between the glass and the emitter sites is evacuated which allows the emission to be controlled using low voltages and this is important for effective spacial control when used in displays.

Emission currents measured in such a device having a

vacuum below 5 x 10^{-6} mbars are shown in Figure 3 which is a graphical representation of the emission current vs the electric field. It is also estimated that the beta factor for the described device is in excess of 450 with this figure including both geometric enhancement and internal enhancement.

The device hereinbefore described is suitable for many display applications having low power consumption and being relatively simple to fabricate. Such devices may also be used as the cathodes for high power transistors for microwave amplifiers in the satellite and mobile communication markets.

Various modifications can be made to the invention as hereinbefore described without parting from the scope of the invention. For example TFT control circuitry can be fabricated in the same manner as the described field emission backplate either at pixel level or via integrated peripheral drivers. It is possible that the field emission device having field emission backplate of the present invention is of the type that embitter sites inject directly into a wide band gap light emitting material to produce light emission. Such arrangements would be particularly useful in the case of the thin film semiconductor not being of N-type and there being no low barrier metal that enables electrons to be injected. The thin film semiconductor of an example given is an N-type

hydrogenated amorphous silicon however the semiconductor may alternatively may be germainiun or germainiun alloy or similar. The substrate on which the thin film semiconductor as disposed has been described as being aluminium however may be formed of various other types of metal such as mobidium, chromium or similar. The use of a KrF (Krypton Fluorine) excimer laser is described however any excimer laser may be used. Further, the use of a Nd:YAG laser at 532 nm is described, however any other wavelength of Nd:YAG laser can be used.

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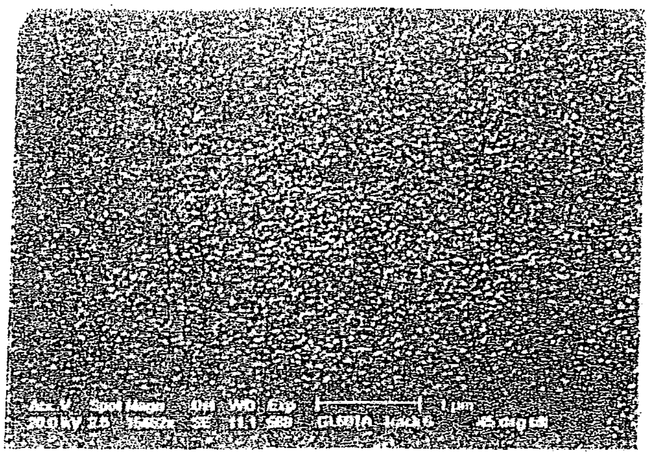

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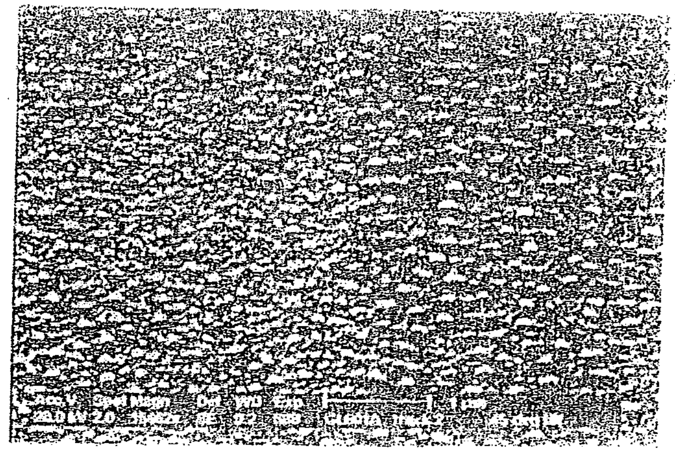
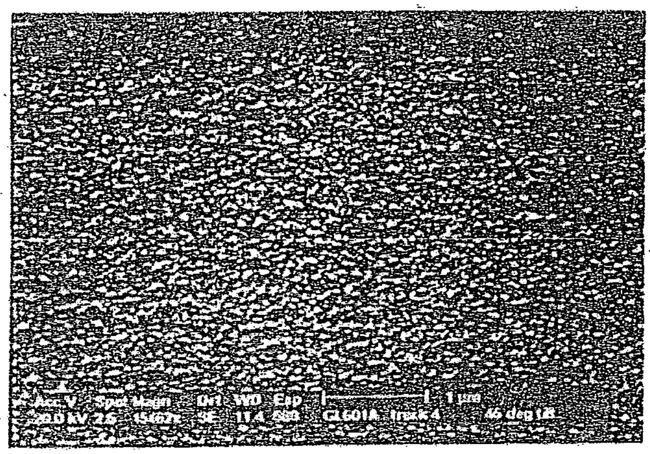
FIGURE 1A



20p/mm

FIGURE 1B



5p/mm

FIGURE 1C

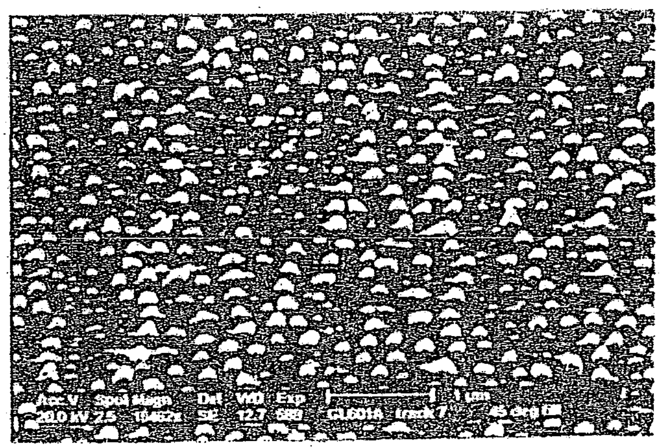


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FIGURE 1D

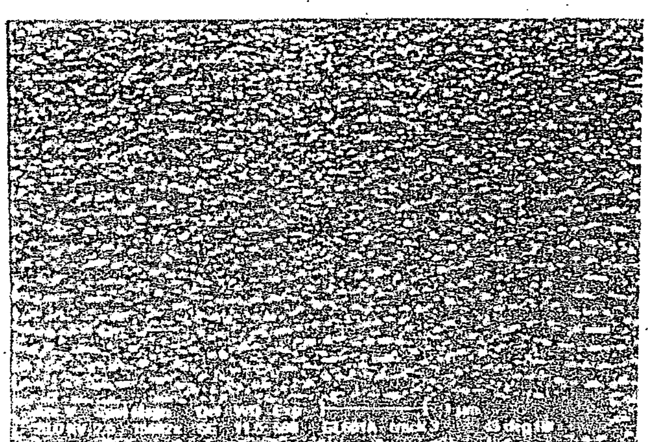

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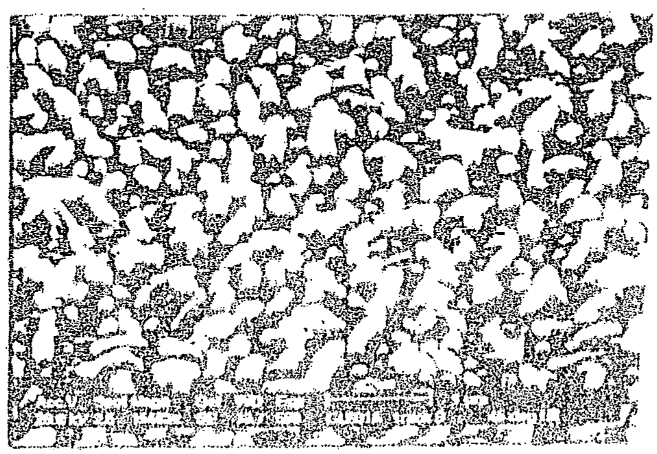
FIGURE 1E



100p/mm

FIGURE 1F

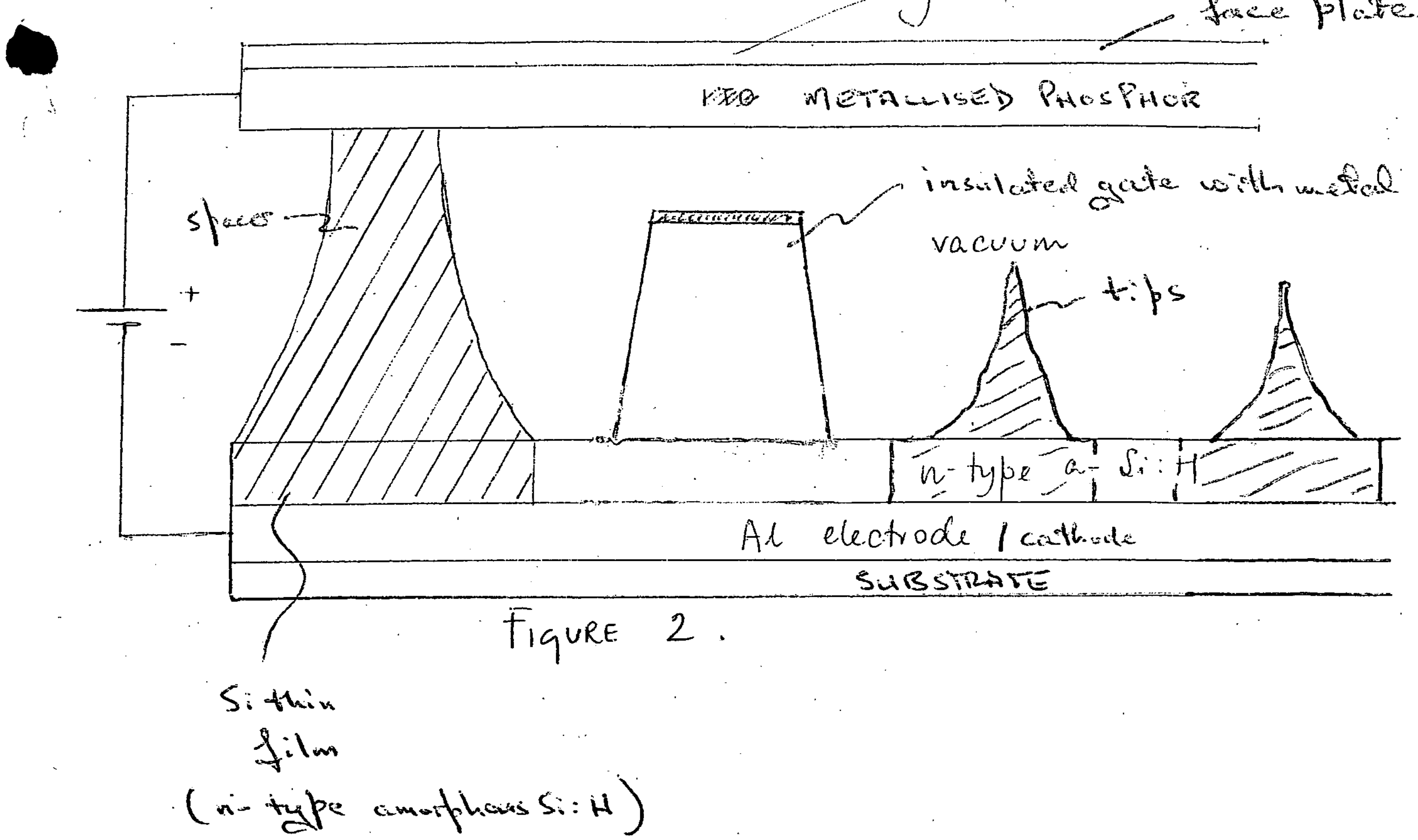


FIGURE 2.

File1

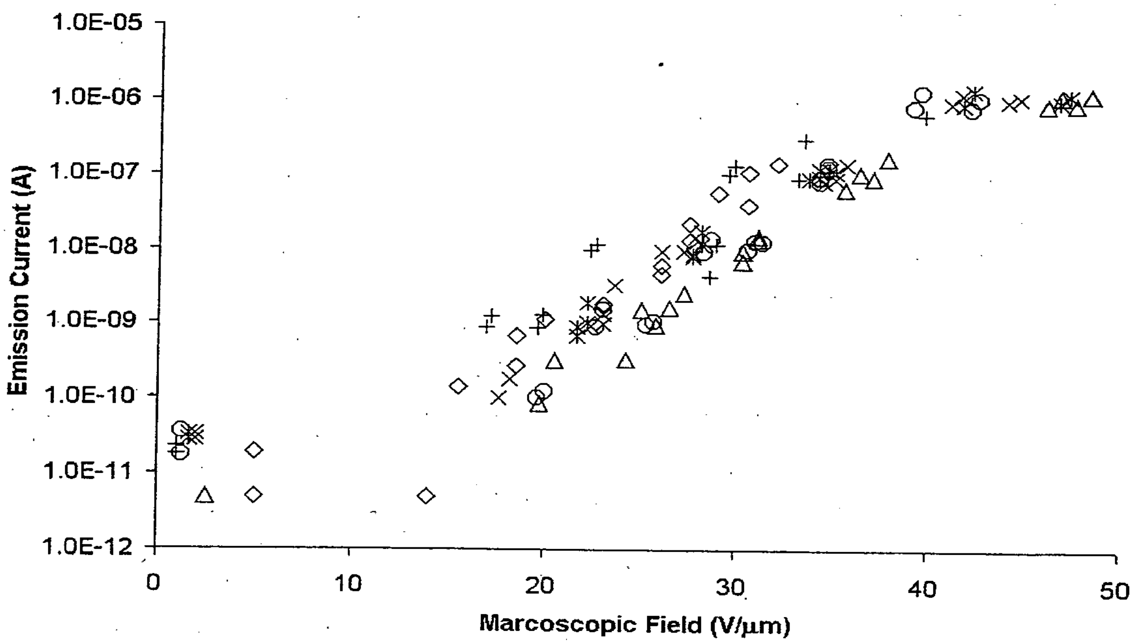


FIGURE 3